Geophysical Research Abstracts,
Vol. 11, EGU2009-14117, 2009
EGU General Assembly 2009

In-situ inventory of gas and gas hydrates in deposits of the Håkon Mosby mud volcano, SW Barents Sea

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Submarine mud volcanoes are an important source and reservoir of methane and other low-molecular weight hydrocarbons (LMWHC). Consequently, mud volcanoes located within the gas hydrate stability zone (GHSZ) are known to host shallow buried gas hydrates in high density. However, gas hydrate inventories in shallow mud volcano deposits are strongly affected by changes in local physico-chemical conditions due to episodic volcanic activity and response by fixation or release of abundant portions of LMWHC.

We determined the in situ gas inventories in shallow deposits of the Håkon Mosby mud volcano (HMMV, SW Barents Sea) in approx. 1,250 m water depth by quantitative degassing of pressure cores recovered with our Dynamic Autoclave Piston Corer. As recognized during previous studies of the HMMV, a concentric arrangement of geochemical parameters and topographic features allow for the distinction of three geomorphological units (I, II, III). During our cruise in summer 2008 we recovered pressure cores (up to 2.65 m below seafloor, b.s.f.) from all the three units and volumetric gas–sediment (wet) ratios ranged between 2.6 in a core taken at the northwestern outer rim (Unit III), and 25.2 obtained for a core in the northeastern section (Unit II). Gas sub-samples collected during degassing of pressure cores belonging to the three units showed C_1/C_{2+} ratios $>1{,}000$ suggestive of a predominantly microbial LMWHC origin. Hydrate stability calculations based on LMWHC distributions, pore water salinities and bottom water temperatures suggest that structure I hydrates are the most stable crystallographic hydrate structure at the HMMV.

Pore water chloride and sulfate profiles combined with in situ temperature data were used to delineate local boundaries of hydrate accumulations in each of the three geomorphologic units. Subsequently, gas volumes in pressure cores were referred to core segments comprising gas hydrates, and hydrate concentrations were calculated.

Low gas hydrate densities of about 5.2% pore volume were found for a station at the active center (Unit I), where the rapid ascent of warm fluids and mud causes high temperatures of up to more than 20°C in near-surface sediments. Hydrate precipitation is assumed to occur in the uppermost much colder sediments. Beyond the center, the transition between warm mud and fluids and the cold bottom water of around –0.8°C expands due to decreasing rates of upward fluid flow, and the GHSZ extends up to several meters b.s.f towards the edges of the morphological unit I. At those sites the upper hydrate limit is controlled by the anaerobic oxidation of methane (AOM), which in turn is controlled by the penetration depth of seawater-derived sulfate. Nevertheless, segments beyond the AOM zone of cores belonging to Unit II (n = 4) contained highest hydrate concentrations of 24.1% of pore volume on average. In contrast, the hydrate bearing segment of a core taken in sediments belonging to Unit III comprised comparably low abundances of 2.9% ps. These hydrate concentrations are taken to extrapolate the overall hydrate volumes stored in shallow deposits of the different morphological zones and, consequently, of the entire mud volcano structure.